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(54) Abstract Title
A motor vehicle having an electric motor for damping torque changes

(57) In a vehicle having an engine 10, a clutch 11 and a gearbox 12 driving the wheels 16 through a propeller shaft 20 an electric motor 13 is provided to supply or absorb torque from the propeller shaft to reduce oscillations in the drive line cause by rapid torque changes. An electronic control means controls the motor 13 on the basis of torque signals from sensors 29, 30, 33 and 34, the back emf of the motor and preprogrammed information regarding the expected torque changes due to driver demand. The motor 13 can be on the input side of the gearbox instead of the output side and can be in line with the driveshaft or connected to it through a belt.

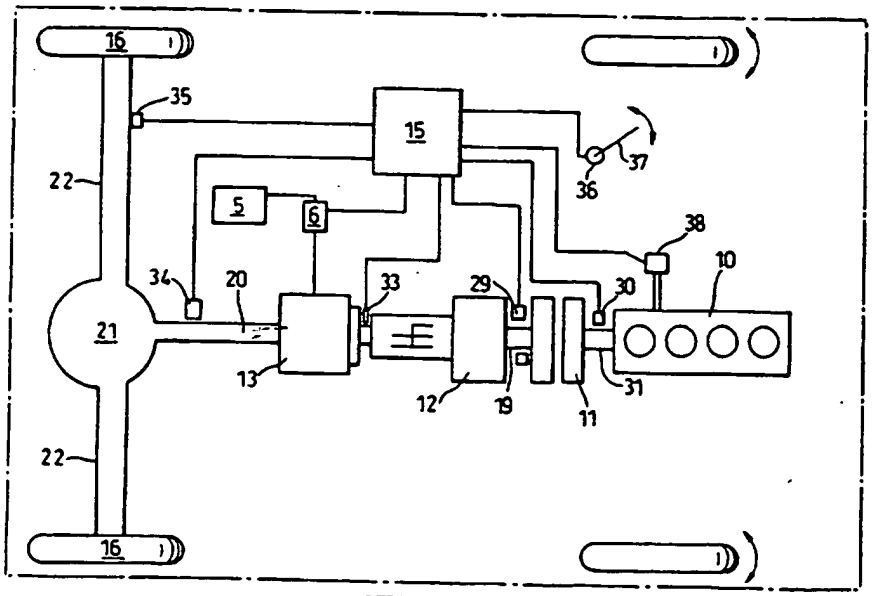

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

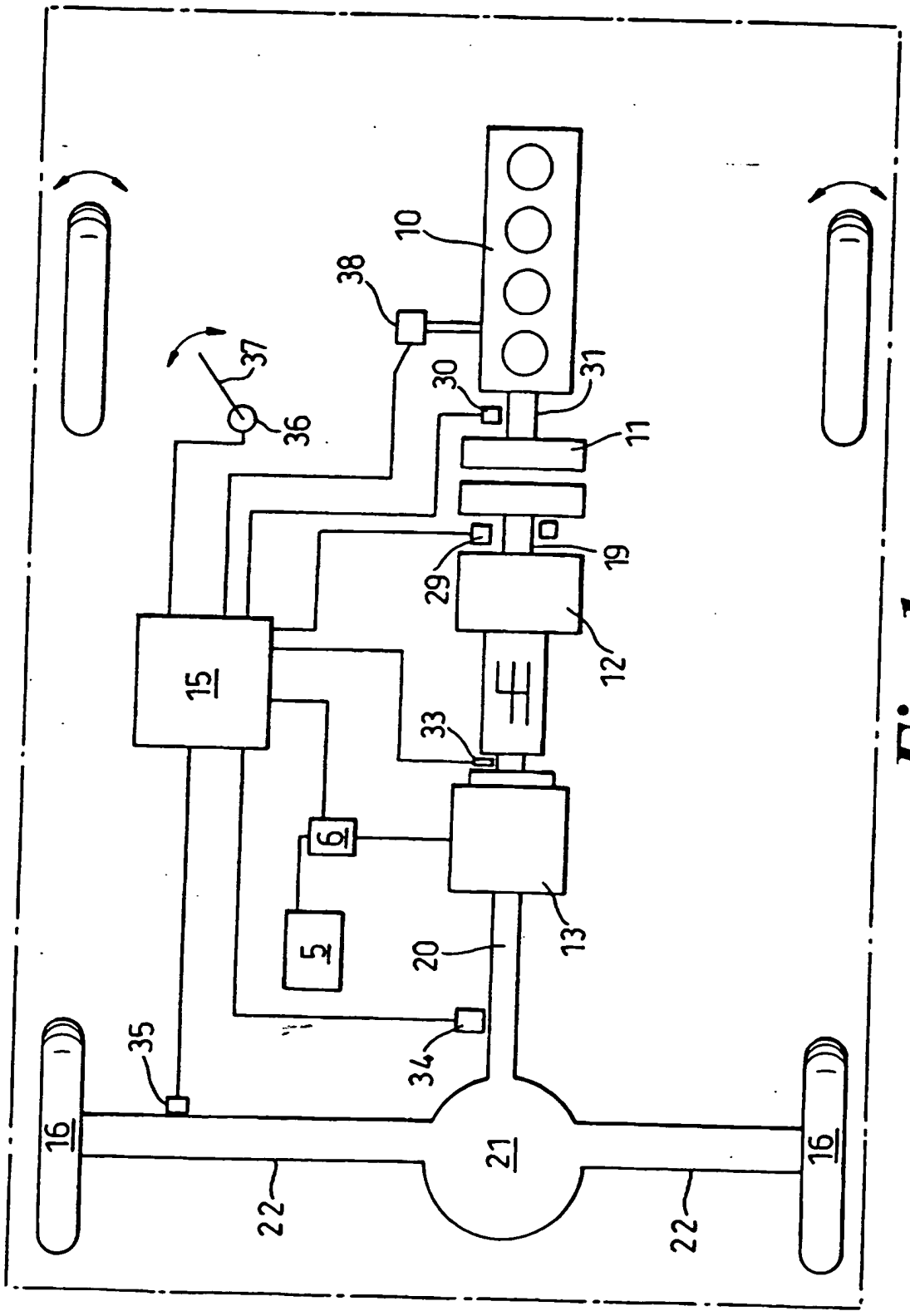

Fig 1

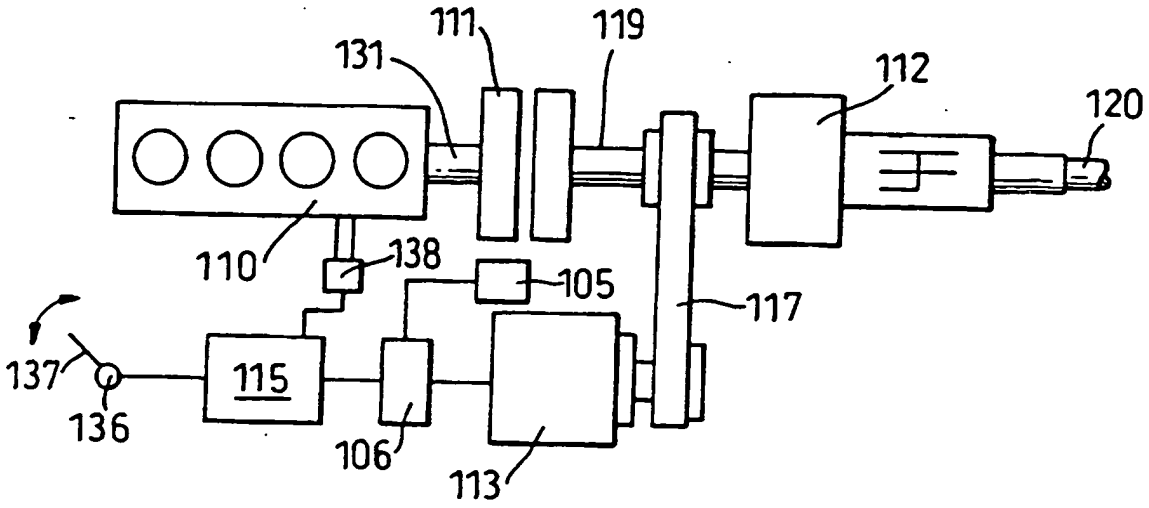

Fig. 2

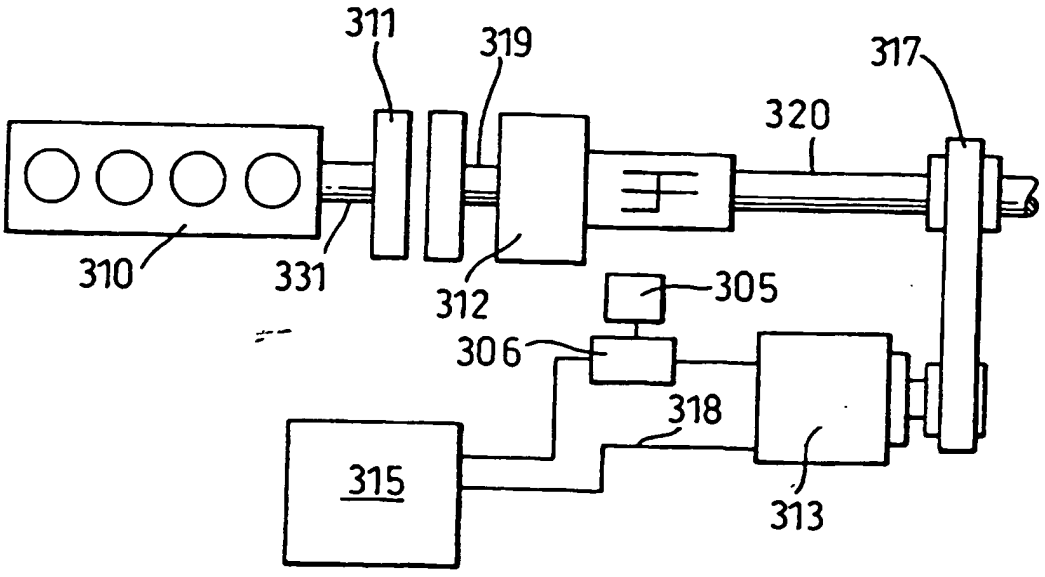

Fig. 3

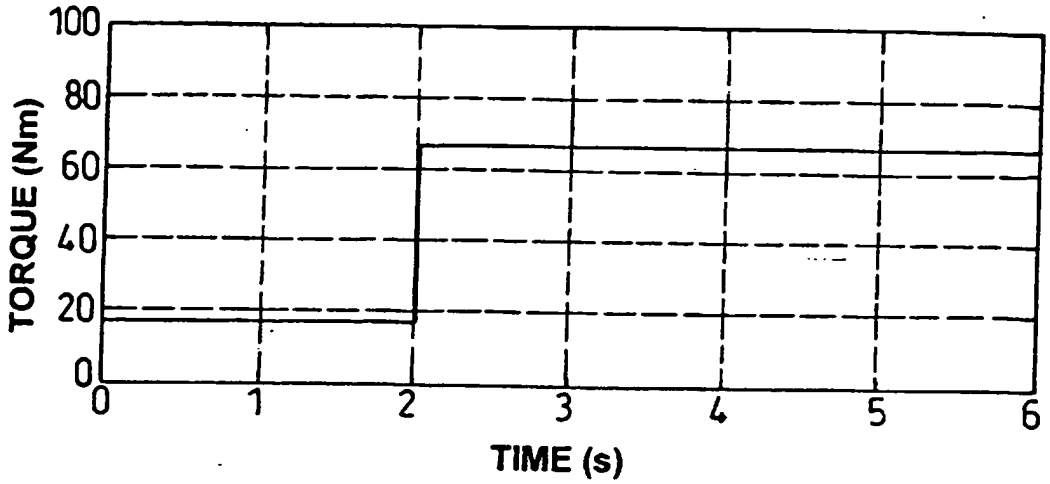

Fig. 4a

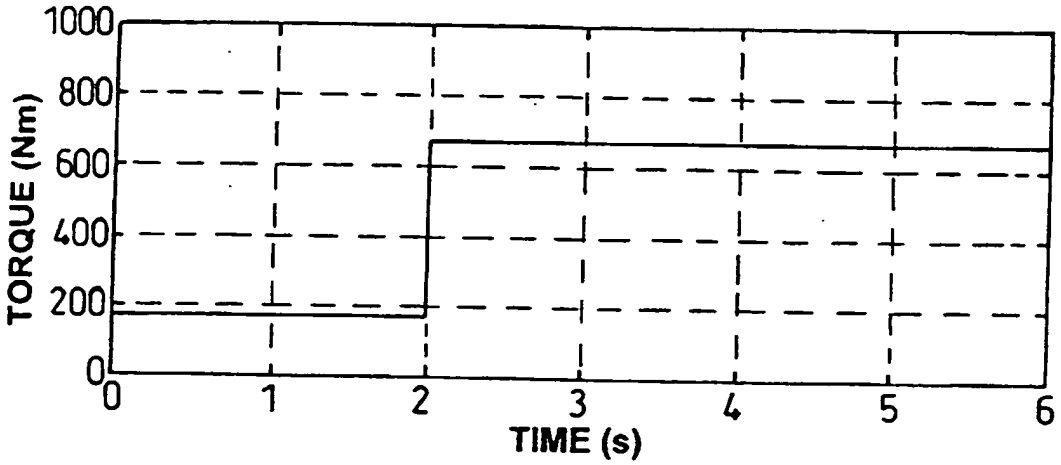

Fig. 4b

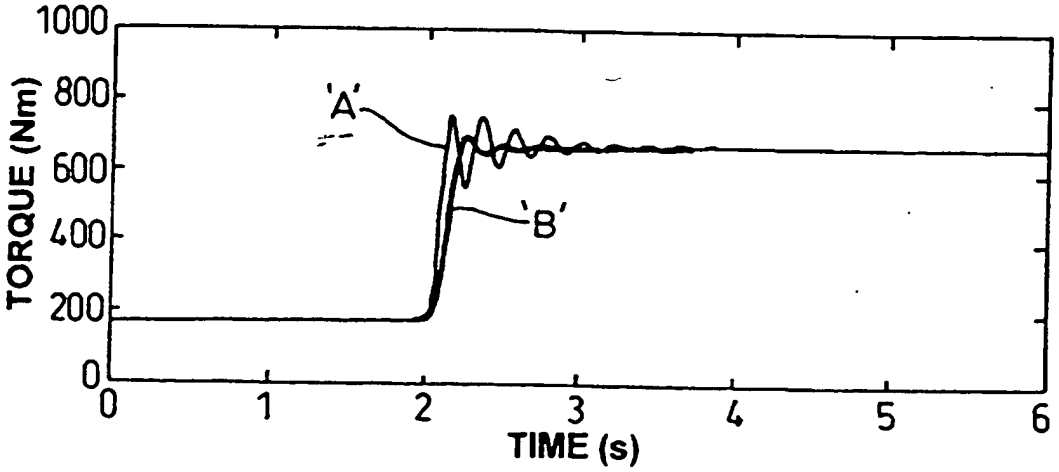

Fig. 4c

A Motor Vehicle and a Transmission System Therefor

This invention relates to a motor vehicle and in particular to a transmission system for a motor vehicle.

It is well known to provide a motor vehicle with an internal combustion engine driving one or more wheels by a multi-speed gearbox and a clutch to selectively connect the engine to the gearbox. In the case of a hybrid motor vehicle an electric motor is arranged to drive the motor vehicle either through the gearbox by means of an output shaft from the gearbox.

It is well known to provide the motor vehicle with drive shafts to connect the gearbox to the driven road wheels of the motor vehicle. Such drive shafts may extend transversely across the vehicle or longitudinally along the vehicle depending upon the particular transmission arrangement and in the case of a four wheel drive vehicle there may be drive shafts extending both longitudinally and transversely.

It is a problem with such a prior art motor vehicle that when a sudden change in driving torque is generated by the internal combustion engine or through a sudden re-engagement of the clutch a considerable amount of wind up occurs in the driveline between the engine and the road wheels which can have a detrimental effect on drive line refinement.

It is an object of this invention to provide an improved transmission system for a motor vehicle.

According to the invention there is provided a motor vehicle having an engine and a transmission system to transmit drive from the engine to one or more driven road wheels wherein the motor vehicle further comprises at least one electric machine to provide a damping effect to the transmission system when a rapid change in torque is detected.

The transmission system may comprise a multi-speed gearbox having an input shaft operatively connected to a clutch and an output shaft operatively connected to a drive means used to transmit drive from the gearbox to one or more driven road wheels of the motor vehicle.

The electric machine may be an electric motor.

The electric motor may be driveably connected to the input shaft of the gearbox or alternatively may be driveably connected to the output shaft of the gearbox.

The electric motor may be controlled by an electronic control means in response to signals indicative of torque measured at one or more positions within the driveline between the engine and the driven road wheels.

The electric motor may be controlled by an electronic control means in response to a signal indicative of demand torque so as to provide simultaneous control of the engine and the electric motor.

The electric motor may be controlled by an electronic control means in response to a signal indicative of the back electromotive force produced by the electric motor.

The invention will now be described by way of example with reference to the accompanying drawing of which:-

Fig.1 is a schematic plan view of a motor vehicle according to a first embodiment of the invention;

Fig.2 is a schematic plan view of part of a transmission system according to a second embodiment of the invention;

Fig.3 is a schematic plan view of part of a transmission system according to a third embodiment of the invention;

Fig.4a is a graph of time versus torque produced by an internal combustion engine during a step change in output torque;

Fig.4b is an idealised graph of time versus torque produced at a driven road wheel due to the step change in torque shown in Fig.4a; and

Fig.4c is a typical graph of time versus torque actually produced at a driven road wheel due to the step change in torque shown in Fig.4a.

With reference to Fig.1 there is shown an internal combustion engine 10 and a transmission system for transmitting from the engine 10 to two driven road wheels 16.

The transmission system is arranged to transmit drive from the internal combustion engine 10 and from an electric motor 13 and has a multi-speed gearbox 12 driven by the engine 10 via a clutch assembly 11.

The clutch assembly 11 is selectively engageable or disengageable by an operating linkage (not shown) to connect or disconnect drive between the engine 10 and an input shaft 19 of the gearbox 12.

The gearbox 12 has an output drive shaft in the form of a propeller shaft 20 to transmit drive from the gearbox 12 to the wheels 16 of the motor vehicle via a differential 21 and two transversely extending drive shafts 22.

The electric motor 13 is arranged to directly drive the propeller shaft 20 and is powered by a battery 5. The power supply to the electric motor is controlled by an electronic control means 15 via a power controller 6.

The electronic control means 15 is arranged to receive signals indicative of the torque produced by the engine 10 from a torque transducer 30 operatively connected to an output shaft 31 of the engine 11.

The electronic control means 15 also receives signals from further torque transducers 29, 33, 34, 35 positioned at various points along the driveline between the clutch 11 and the driven road wheels 16.

The electronic control means 15 also receives a signal indicative of driver demand from a sensor 36 attached to an accelerator pedal 37. The electronic control means 15 is operable to send a signal to an engine fuel supply system 38 in response to the signal received from the sensor 36.

In use, the electronic control unit 15 is arranged to control the electric motor 13 so as to prevent the rapid transfer of torque from the engine 10 to the propeller shaft 20 and to the drive shafts 22 so as to reduce the amount of overshoot or wind-up that will occur in these components.

When overshoot is occurring the electric motor 13 is energised to work against the motor 10 and when undershoot is sensed to be occurring the electric motor 13 works with the engine 10. In this way a more uniform transfer of torque from the engine 10 to the driven road wheels 16 occurs.

The effect of this use of the electric motor 13 as an active damper is shown in Fig.4C by the line "B" in comparison with the under damped response shown by the line "A".

This is achieved by monitoring the torque produced using the sensors 30, 33 and its effect on the driveshafts 22 using the sensor 35 and initiating active damping when a disparity between the produced torque and the transmitted torque develops. This disparity will be

produced by wind-up or torsional deflection of the drive shafts 20, 22 that is used as the method of measuring the torque in these components.

With reference to Fig.2 there is shown a second embodiment of the invention in which a motor vehicle has an internal combustion engine 110 and a transmission system for transmitting drive from the engine 110 to two driven road wheels (not shown).

The transmission system is arranged to transmit drive from the internal combustion engine 110 and from an electric motor 113 and has a multi-speed gearbox 112 driven by the engine 110 via a clutch assembly 111.

The clutch assembly 111 is selectively engageable or disengageable by an operating linkage (not shown) to connect or disconnect drive between the engine 110 and an input shaft 119 of the gearbox 112.

The gearbox 112 has an output drive shaft in the form of a propeller shaft 120 to transmit drive from the gearbox 112 to the driven wheels of the motor vehicle.

The electric motor 113 is arranged to drive the input shaft 119 of the gearbox 112 by means of a drive belt 117.

The electric motor 113 is powered by a battery 105 and is controlled by an electronic control means 115 connected to a power controller 106.

The electronic control means 115 is arranged to receive a signal indicative of driver demand from a sensor 136 attached to an accelerator pedal 137 and send a signal to an engine fuel supply system 138 in response to the signal received from the sensor 136.

In use, the electronic control means 115 is programmed to control the electric motor 113 in response to the signal produced by the sensor 136 attached to the accelerator pedal 137 so as to prevent the rapid transfer of torque from the engine 110 to the propshaft 120.

The electronic control means 115 is pre-programmed with the likely driveline response to numerous changes in driver demand and from this pre-programmed information it can control the electric motor 113 to dampen out excessive oscillations by either resisting rotation of the input shaft 119 or by providing a positive drive to the input shaft 119 depending upon the predicted state of the driveline. For example, if overshoot is predicted to occur the electric motor is energised to resist rotation of the propeller shaft 120 whereas if undershoot is predicted to occur the electric motor 113 is energised to produce a positive drive to the propeller shaft 120 in the same direction as the torque applied by the engine 110.

In this way the electric motor 113 acts an active damper to reduce driveline oscillations and improve driveline refinement.

The electronic control means may further comprise an ability for adaptive tuning so as to allow for changes in the characteristics of the transmission system due to variation in vehicle load, tyre pressures or othe parameters having an effect on its dynamic response.

With reference to Fig.3 there is shown a third embodiment of the invention in the form of a motor vehicle having an internal combustion engine 310 and a transmission system for transmitting drive from the engine 310 to a pair of driven road wheels (not shown) of the motor vehicle.

The transmission system is arranged to transmit drive from the internal combustion engine 310 and from an electric motor 313 and has a multi-speed gearbox 312 driven by the engine 310 via a clutch assembly 311.

The clutch assembly 311 is selectively engageable or disengageable by an operating linkage (not shown) to connect or disconnect drive between the engine 310 and an input shaft 319 of the gearbox 312.

The gearbox 312 has an output drive shaft in the form of a propeller shaft 320 to transmit drive from the gearbox 312 to the driven road wheels of the motor vehicle.

The electric motor 313 is arranged to drive the propeller shaft 320 by means of a chain drive 317 and is powered by a battery 305. An electronic control means 315 is used to control the electric motor 313 via a power controller 306.

The electronic control means 315 is arranged to receive by means of a link 318 a signal indicative of the back electromotive force produced in the electric motor 313.

As is well known in the art there is no fundamental difference between an electric generator and an electric motor. In fact the only significant difference is that in a generator the electromotive force generated by rotation of the rotor is greater than the terminal voltage, whereas in an electric motor the electromotive force is less than the terminal voltage.

The magnitude of the electromotive force produced in such an electric machine is proportional to the speed of rotation of the rotor and can therefore be used to measure the speed of rotation of the rotor from which variations in transmitted torque can be calculated.

In use, the electronic control means 315 is arranged to control the electric motor 313 so as to prevent sudden changes in the torque of the propeller shaft 320 by using the signal received from the electric motor 313 as an indication of the rotational speed of the propeller shaft 320.

When the electronic control means 315 senses that the rate of change of rotational speed and hence the torque of the propeller shaft 320 is greater than a level known to be likely to

produce oscillations within the driveline of the motor vehicle the electric motor 313 is energised via the power controller 306 to reduce the rate of acceleration by acting as a generator to recharge the battery 305. This applies a torque to the propeller shaft 320 in opposition to the torque applied by the engine 310.

When a sudden de-acceleration in the rotational speed of the propeller shaft 320 occurs this is sensed by the electronic control means 315 by the sudden drop in the back electromotive force produced by the electric motor 313. The electronic control means 315 interpretes this reduction as a drop in torque and operates so as to energise the electric motor 313 by the power controller 306. The electric motor 313 then draws current from the battery 306 and applies an assisting torque to the propeller shaft 320 so as to increase the acceleration of the propeller shaft 320.

The effect of this selective use of the electric motor 313 as a motor or as a generator is to use the electric motor 313 as an active damper so as to damp out driveline oscillations.

The use of the term "electric machine" as meant herein refers to an electric motor or a an electric generator having a rotatable rotor.

CLAIMS

1. A motor vehicle having an engine and a transmission system to transmit drive from the engine to one or more driven road wheels wherein the motor vehicle further comprises at least one electric machine to provide a damping effect to the transmission system when a rapid change in torque is detected.

2. A motor vehicle as claimed in Claim 1 in which the transmission system comprises a multi-speed gearbox having an input shaft operatively connected to a clutch and an output shaft operatively connected to a drive means used to transmit drive from the gearbox to one or more driven road wheels of the motor vehicle.

3. A motor vehicle as claimed in Claim 1 or in Claim 2 in which the electric machine is an electric motor.

4. A motor vehicle as claimed in Claim 3 when dependent upon Claim 2 in which the electric motor is driveably connected to the input shaft of the gearbox.

5. A motor vehicle as claimed in Claim 3 when dependent upon Claim 2 in which the electric motor is driveably connected to the output shaft of the gearbox.

6. A motor vehicle as claimed in Claim 3 in which the electric motor is controlled by an electronic control means in response to signals indicative of torque measured at one or more positions within the driveline between the engine and the driven road wheels.

7. A motor vehicle as claimed in Claim 3 in which the electric motor is controlled by an electric control means in response to a signal indicative of demand torque so as t provide simultaneous control of the engine and the electric motor.

8. A motor vehicle as claimed in Claim 3 in which the electric motor is controlled by an electronic control means in response to a signal indicative of the back electromotive force produced by the electric motor.

9. A motor vehicle substantially as described herein with reference to the accompanying drawing.

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Application No:	GB 9902577.7	**Examiner:**	Tom Sutherland
Claims searched:	1 - 8	**Date of search:**	19 October 1999

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B7H (HDE), F2D (DCA), F1B (BBA)

Int Cl (Ed.6): B60K41/00, F16F 15/18

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0743215 A	(TOYOTA) Whole document relevant, note col. 2 lines 47 to 50.	1, 3, 7. 8
X	EP 0175952 A	(MAZDA) Whole document relevant.	1, 3
X	WO 98/31559 A	(ROVER) See claim 1, Fig. 1 and page 4 line 21.	1 - 3, 5
X	WO 97/08477 A	(CLOUTH) See Figs 1 and 5.	1 - 4, 6
X	US 5713425	(FORD) Note col. 4 lines 1 to 8 and 45 to 53.	1 - 3, 5, 7
X	US 5185543	(FICHTEL & SACHS) Whole document.	1 - 4

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